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The study of fracture patterns can yield information concerning both regional and local structural features developed in the crust of the earth. Such a study requires that relatively standardized field techniques be applied to certain geologic settings in order to be most effective. First, fracture patterns must be studied on a regional basis to determine the vertical and areal configuration of the regional fracture pattern. Second, such a study is most advantageously carried out in an area of reasonably gentle deformation containing a relatively simple regional fracture pattern. An area which has undergone intense deformation and/or metamorphism would tend to have a too complex and incompletely preserved fracture pattern which would make detailed fracture pattern analysis virtually impossible. Third, detailed studies of all types of local structural features present must be carried out in order to determine if there are unique fracture patterns associated with these structures and what relationship these fracture patterns bear to the regional fracture pattern.

Northwest Arkansas is an ideal area for a fracture pattern study. As a result of field work carried out in the summer of 1961 in northwest Arkansas and subsequent analysis of the data gathered, the regional fracture pattern of this area has been established, and the existence of unique fracture patterns of smaller order in northwest Arkansas has been recorded.

Regional Shear Fracture Patterns of Northwest Arkansas

The regional shear fracture pattern of northwest Arkansas is made up of five component sets. These sets have the following average strikes and stratigraphic extent: Set 1a strikes N 55° E and is present from the Pre-Cambrian into Permian age rocks; Set 1b strikes N 30° W and is present from the Pre-Cambrian into the Permian rocks; Set 2 strikes N 5° W and is present from the Pre-Cambrian into the Atoka Formation (Pennsylvanian); Set 3a strikes N 70° W and is present from the Pre-Cambrian through the Boone (lower Mississippian); Set 3b strikes N 7° E and is present in the rocks from the Pre-Cambrian through the Boone (lower Mississippian). A numerical designation was assigned to each set for convenience, and each set will be hereafter referred to by these numbers.

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Sets 3a and 3b are the oldest shear fracture sets in northwest Arkansas. These sets are roughly contemporaneous and are interpreted to be immediately post-Boone in age. Application of the strain ellipsoid to these sets of shear fractures indicates a compressional force operative in a northwest-southeast direction. This force corresponds in direction to the force necessary to produce the northeast trending set of folds mapped in northwest Arkansas (4). Inasmuch as these folds are expressed in rocks of Morrowan Age they must be as young as the Morrowan (4). The difference in age of the shear fractures and the folds may be explained by the hypothesis that shear fractures are produced by the initial impulse of the applied compressional force which ultimately produced northeast trending folds of Morrowan Age.

Sets 1a, 1b and 2 were generated during Pennsylvanian and Permian time. These sets have been attributed to compressional forces associated with the Ouachita orogeny (3). Sets 1a and 1b fulfill the conditions of the strain ellipsoid and would indicate a north-south compressive force. Set 2 fulfills the qualifications for shearing parallel to the direction of a compressional force acting in a north-south direction (2). Sets 1a, 1b, and 2 correspond generally in age to the time of formation of the east-west trending folds of northwest Arkansas (1, 5).

The shear fractures of the regional patterns may be recognized in several ways. Shear fracture planes are generally straight or very smoothly curved. These shear fractures cut through local differences of composition, tenacity, and density, in the rock without appreciable deflection. Shear fractures are generally tightly closed unless they have been opened by secondary solution or by secondary movement. Shear fractures are never observed to be offset at their intersection with bedding planes or other planes of weakness in the rock.

Fracture Patterns Associated With Folds and Faults

Tension fractures which are unrelated to the regional fracture pattern of northwest Arkansas are frequently associated with local structures. These tension fracture patterns have the gross configuration of belts of fracturing encompassing the trend of the associated structures. Maximum concentration of fracturing occurs in the vicinity of maximum deformation with fracturing becoming less dense with distance perpendicular to the area of maximum deformation. Density of fracturing and width of the fracture belt are mutually dependent upon the magnitude of the structure and on the brittleness of the rock in which the fracture pattern is expressed. Tension fractures may be recog-

nized by their rough and angular fracture planes, which are considerably more open than those of shear fractures, and by the presence of offsetting of the fracture planes at their intersection with other planes of weakness in the rock.

Tensional Fracture Patterns Associated with Faults

Two sets of tension fractures comprise the fracture pattern associated with faults. The best developed and most dense set of tension fractures are generally developed parallel to the strike of the fault. A less dense, less well-developed set of tension fractures is usually developed perpendicular to the strike of the fault. Thus a roughly rectangular fracture pattern is expressed with the long axis of the rectangle parallel to the trend of the fault.

The tension fractures are interpreted to be the result of the tensional stress field responsible for gravity faulting. Displacement identical to that of the fault has occurred along these tension fractures at some localities. This relationship indicates the possibility of a genetic relationship between the tension fractures and the larger faults.

Fractures Associated with Collapse Structures

A detailed study of a collapse structure located in the city of Fayetteville near Lake Lucille was carried out in the fall of 1961. A very dense tension fracture pattern was observed along the limbs of this structure. Along steeply dipping portions of the limbs near the axis of the structure the fracture pattern was chaotic. Farther away from the axis of the structure the fracuring is more systematic resembling the rectangular fracture pattern associated with faults. This structure, which resembles a normal tectonically produced syncline, is thought (Quinn, J. H., 1961, Personal Communication) to be the result of collapse due to solution of soluble rocks at depth. The tension fractures are the result of tensional forces produced by the lengthening of rock necessary to produce a synclinal configuration from originally flat-lying rocks.

Tension Fractures Associated with Folding

A concentration of tension fractures was observed parallel to the strike of the fold along the axial region of anticlines and monoclines. These fracture patterns consist primarily of a set of fractures parallel to the strike of the fold with an extremely poorly developed set perpendicular to the strike of the fold.

Conclusions

Until the close of Boone time the rocks of northwest Arkansas were not systematically fractured. Immediately following

Boone time a compressional force was exerted on the rocks acting in an essentially northwest-southeast direction and Sets 3a and 3b were generated. From this time until at least Atoka time the rocks that were deposited were not systematically fractured. Between the beginning of Atoka time and Permian time compressive stresses were again active and Set 2 was generated. Sets 1a and 1b were generated after Set 2 and are at least as young as Permian. Thus, two general periods when compressive forces were active are indicated by the presence of shear fractures. That these times were the only times of diastrophic activity cannot be determined since it is not known whether rocks being deformed under conditions of deep burial are subject to shear fracturing. That such rocks are subject to shear fracturing at the maximum depth of burial encountered in northwest Arkansas is indicated by the fact that the shear fracture sets penetrate the entire stratigraphic column. These two periods of shear-fracturing correspond roughly to the two recognized periods of folding in northwest Arkansas. The first appearance of these fracture patterns, especially in the case of Sets 3a and 3b, precede the youngest expression of the associated set of folds and may be explained by the hypothesis that fracturing occurs as a result of the initial impulse of force responsible for folding.

The tensional fracture patterns associated with local structures are interpreted to be contemporaneous with the formation of the structures. Thus, it is possible to assign a relative age to these local structures by observing the cross-cutting relationships of the tension fractures and the regional shear fractures of known age. Furthermore, the trend of faulting is invariably parallel to the long dimension of the rectangular fracture patterns associated with faulting.

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